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Charging infrastructure for residents in multi-unit residences: Analysing the situation in Germany

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Many countries have set targets for deploying battery-electric vehicles (BEVs) to meet net-zero goals. In this context, the availability of charging infrastructure for residents of multi-unit residences (MURs) becomes increasingly relevant. However, the installation and use of charging infrastructure in MURs is still scarce and challenging. This study examines the current state of charging infrastructure deployment in MURs and tenants' as well as owner-occupiers' preferences for both current users and non-users of a BEV in Germany. Based on a survey with 1,035 tenants and 437 owner occupiers living in MURs, we analyse the current state of driving, parking, charging, and charging infrastructure as well as the residents' preferences for different charging solutions and distances, and identify barriers based on these findings. We derive implications for decision-makers in policy, industry, and academia to accelerate the uptake of charging infrastructure in these buildings.

Keywords: Electric vehicles, consumer behaviour, consumer demand, optimal charging locations, social equity

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1 Introduction

The deployment of battery-electric vehicles (BEVs) is essential for decarbonizing the transport sector and a net-zero future. Hence, many countries have set targets for BEV deployment. Germany, for example, aims for 15 million electric cars on the roads by 2030, which is at risk due to currently stagnating shares in new BEV registrations [1]. One major barrier to the purchase of an electric vehicle is the perceived lack of charging infrastructure [1–3]. In Germany, 50 to 80 percent of charging events currently occur at BEV users' homes. The majority of these users are home-owners and often have the ability to produce their own electricity via photovoltaic systems [4, 5]. However, more than half of all homes are multi-unit residences (MURs)[1] in Germany [6]. Similar situations can also be found in other countries such as the United States, where also nearly 80% of charging processes occur at the BEV users' home while 31% of the households live in MURs [7]. Hence, to achieve a further ramp-up of BEVs and new user segments beyond the early adopters, charging at MURs will be essential.

Regulatory efforts and initiatives have been employed to increase the deployment of charging infrastructure at MURs, e.g., the Energy performance of Buildings Directive (EPBD) at European level or the "Charge at home" initiative in the US [8]. However, the deployment of charging infrastructure at MURs is typically still low. For example only 7% and 5% of MURs are equipped with charging points in Germany and the

[1] Extant work often also refers to the same phenomenon as multifamily houses. Multi-unit dwellings, or multi-unit residential buildings.

United States, respectively [9, 10]. Public charging points, which have also been supported by governments [11], might serve as complementary solutions. Despite the potential and these activities, BEV deployment in multi-family houses still lags in many countries [12]. In Germany, for example, the share of BEV users charging at home is substantially higher in single-family houses (90%) than in MURs (55%) [13], indicating the need for a better understanding of the current situation, as well as respective drivers and barriers.

Previous research has started to investigate charging at MURs. While several studies have focused on technical aspects by investigating its general potential [14], simulating load curves and charging simultaneity [15] or examining general dynamics and dependencies of individual process steps when installing charging infrastructure [16], research has also identified several challenges and areas for action. For example, outdated building electrics or insufficient grid connection capacities can complicate or prevent measures to install charging stations [12] and business models need to be sufficiently attractive for users [17]. Moreover and further adding complexity to the issues, spatial conditions are heterogenous: not all residents in MURs have or (will) need their own parking space for a BEV [12] and BEV owners without their own parking space depend on shared charging points or public charging stations within reach further complicating the situation. More generally, Lopez-Behar et al. [18] identified four key areas of action where there are currently challenges for charging in MURs: the installation of the charging infrastructure (including financing), the limitations imposed by the building, the regulatory environment and the availability of parking space. In the US, a best practice guideline [19] highlights stakeholder and technical complexity, parking logistics, cost and limited information and motivation as challenges. Very recently, a review focusing on peer-reviewed and grey literature in the US and Canada was published [12], which also addresses the management of MURs infrastructure and the acceptance of important stakeholders, such as building managers, as well as investigated the acceptance of BEVs, especially by current non-users, and their current needs. Yet, extant work only marginally understands the user perspective such as their needs and preferences, for example regarding different charging solutions, distances or business models, which is particularly important due to the "lack of one-size-fits-all solutions" [12, p. 12], and potential differences between different user groups.

Therefore, this paper aims to identify the current state of charging infrastructure deployment in MURs and tenants' as well as owner-occupiers' preferences in this context. More specifically, we focus on the current state of driving, parking, charging, and charging infrastructure as well as preferences for charging infrastructure development for both current users and non-users of a BEV. We also identify barriers for stakeholders, tenants, and owner-occupiers to invest in charging infrastructures based on these initial findings. A more detailed understanding of the situation of current and future BEV adopters is important to design (policy) measures to increase BEV deployment in MURs and thus to accelerate the decarbonization of transport.

We focus on the case of Germany because it has ambitious targets regrading BEV diffusion which are currently at risk despite German's potential for the diffusion of BEVs in MURs. Moreover, Germany has started to employ regulation regarding the deployment of charging infrastructure at MURs, such as the Building Electric Mobility Infrastructure Act (GEIG), (which entered into force in 2021 and will now be revised due to stricter requirements on European level with the amendment of the EPBD) focusing on renovated and new buildings. Yet, the potential for BEV deployment in MURs has not yet been exploited, which might be explained by several factors such as less consideration given to charging infrastructure at existing MURs and the still complex process for implementing charging infrastructure for tenants--despite changes in German tenancy law. We thus see a need for a better understanding and more nuanced policy advice in Germany.

2 Method

To this end we targeted both users and non-users of BEVs through an online questionnaire that included a range of closed and open-ended questions. The study was fielded between March 28th and April 9th, 2025. Study participation took about 13 minutes on average. We recruited a total of 1,472 participants, among these 1,035 tenants and 437 owner occupiers living in MURs in Germany (i.e., at least two different tenants in one house). All participants were car owners (ICE[2] car and/or BEV) and most of them (73%) had their own parking space. The participants were recruited by a market research institute and compensated for participation.

Table 1: Participants' socio-demographic characteristics

Category	Share in sample (N = 1472)	Share in population
Gender		
Male	50.5% (N = 725)	49.0%
Female	49.3% (N = 744)	51.0%
Non-binary	0.2% (N = 3)	
Age[3]		
18-24	6.7% (N = 98)	9.0%
25-44	31.7% (N = 467)	31.0%
45-64	34.4% (N = 506)	33.0%
65+	27.2% (N = 401)	27.0%
Monthly net household income		
< 1,300€	11.8% (N = 174)	13.0%
1,300€ - < 2,600€	32.4% (N = 477)	30.0%
2,600€ - < 3,600€	19.6% (N = 288)	18.0%
3,600€ - < 5,000€	18.3% (N = 270)	17.0%
5,000€ or more	17.9% (N = 263)	22.0%
Tenants	70.3% (N = 1,035)	84.0%
Owner-occupiers	29.8% (N = 433)	16.0%
Apartment building built 2021 or later	7.4% (N = 109)	2.5%
Number of cars in household	M = 1.3, SD = 0.6, MD = 1, Min = 1, Max = 9	M = 1.15
Current situation		
Working	59.7% (N = 879)	55.4%
Apprenticeship / studying	5.7% (N = 84)	1.6%
Other	34.4% (N = 506)	39.6%

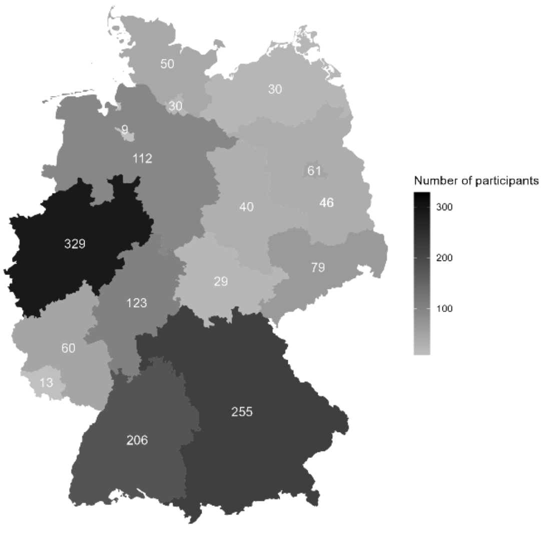

Figure 1. Number of participants in the German federal states

[2] ICE = internal combustion engine

[3] M = 50.4, SD = 17.5, MD = 52, Min = 18, Max = 99

We implemented quotas on gender, age, and income, as well as the federal state to ensure representativity regarding the German population. Our sample was close to representative on these four aspects, with people under 25, people with a monthly net household income of more than 5,000 € and people from two federal states being slightly underrepresented. Table 1 provides an overview of the participants' socio-demographic characteristics and Figure 1 shows their distribution across the German federal states. After the participants agreed to the terms of participation and answered the quota variables, we collected information on their current situation of living, working and mobility, driving, parking and potentially also charging behaviour for the currently most often used car as well as for their electric vehicle (if applicable). Subsequently followed a set of questions asking for their preferences for different charging infrastructure solutions, regardless of whether the respondents owned an electric vehicle or not, including maximally acceptable charging cost. Then, the respondents were asked about current charging infrastructure implementation activities in their municipality and (potentially) by their landlords.

3 Results

3.1 Current mobility and parking situation

Of the 1472 respondents, 179 (12.2%) currently drive a BEV, with 67 (37.4%) driving a BEV as a second car. The share of 12.2% is substantially higher than the share of electric vehicles on the German car stock, which stands at 3.3% [20], and one household approximately owns 1.15 cars [21]. The group of BEV drivers mainly consists of people with a net monthly household income of 3,600€ or more (69%).

Overall, 72.8% (N = 1072) of the sample have access to a permanent parking space. Among the owner-occupiers, this share amounts to 91.1%, and among the tenants it amounts to 65.1%. 16.6% (N=177) of these permanent parking spaces are equipped with a wallbox - 104 out of these 177 respondents drive a BEV and further 23 a plug-in hybrid (PHEV). This means that not all installed wallboxes are in use, nor do all electric car drivers own one—only 58.8% of BEV drivers have access to a wallbox. 13.8% of the permanent parking spaces are prepared for charging infrastructure installations, either with ducting (5.1%) or cabling (8.7%). The remaining 66.4% of the permanent parking spaces are neither equipped with nor prepared for charging infrastructure. Note that only less than 8% of the study participants live in a MUR built in 2021 or later, which is when the GEIG in Germany came into effect, regulating the requirements for equipping new and renovated buildings with charging infrastructure [22].

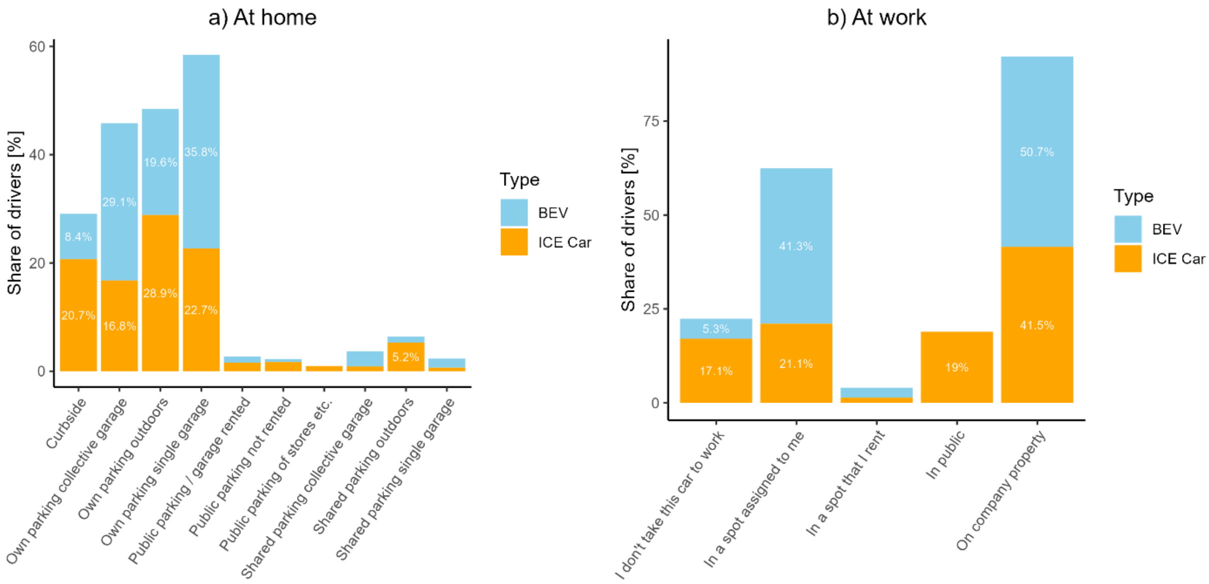

Figure 2. Most popular parking locations at home (a) and at work (b) for ICE and electric cars

Figure 2 shows the most popular parking locations for BEVs and ICE cars at home (Figure 2a) and at work (Figure 2b). At home and in total (BEV and ICE car users, percentages not depicted in Figure 2), vehicles are most often parked in their own parking space (mentioned as the most often used parking location in 70,2% of the total answers[4]), i.e., in collective garages (18.2%), outside (27.8%) and in single garages (24.2%). Curbside parking was mentioned in 19.3% as most often used parking locations and public and shared parking solutions have only been mentioned in 10.6% of the answers. Regarding parking at home, we find substantial differences between BEV and ICE car drivers (Figure 2a). BEV drivers substantially less often park at the curbside (8.4%) compared to ICE car drivers (20.7%) and substantially more in own collective or single garages (64.8%) compared to ICE car users (39.4%). On average, ICE drivers reported a distance of 91 meters (MD = 20, SD = 233) between their most frequently used parking location and their home, while BEV drivers reported a greater average distance of 212 meters (SD = 386, MD = 31). At work and in total (BEV and ICE car users, percentages not depicted in Figure 2), most parking takes place on company property (43.0%) or at a spot assigned to the respective person (24.3%). We also find differences between BEV and ICE car users here (Figure 2b). The own parking spot is more important for BEV drivers (41%) compared to ICE car drivers (21.1%), who also often park in public at work (19.0% of the cases). Parking in public at work was not at all mentioned by BEV drivers. BEV drivers also take their car to work more often (94.7%) than ICE drivers (82.8%).

Figure 3 shows the most popular parking locations at home for ICE cars and BEVs, split between different degrees of urbanization. Across all degrees of urbanization, cars are most often parked on own premises. However, in urban areas, cars are more often parked at the curbside if no other parking is available. This is especially true for ICE cars.

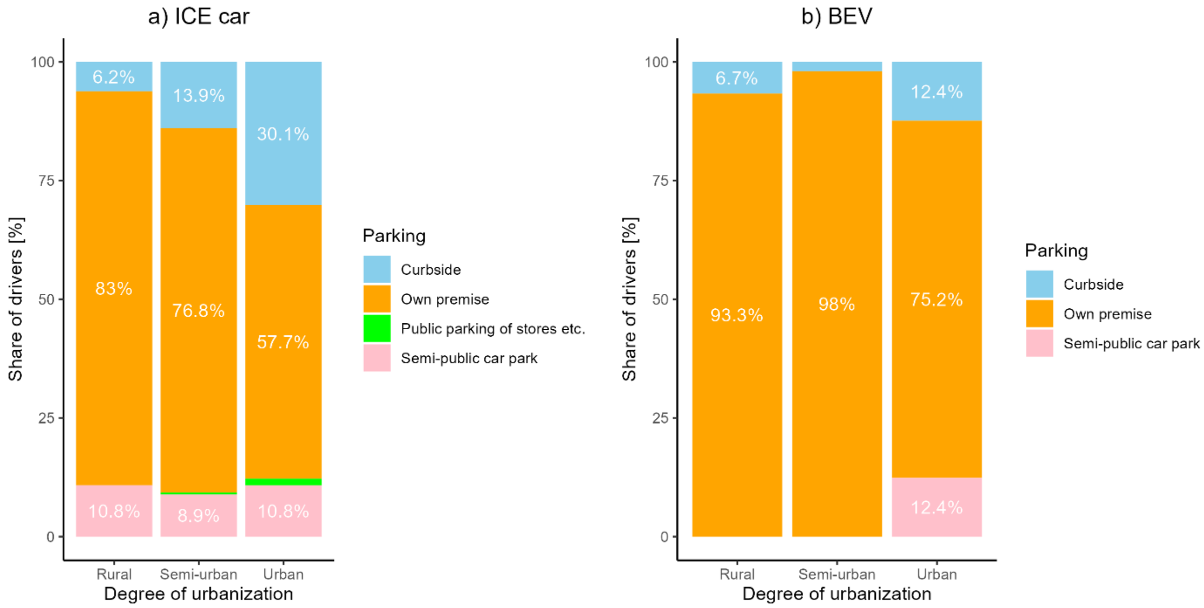

Figure 3. Most popular parking locations at home for ICE cars (a) and electric cars (b)

In addition to parking locations, BEV drivers were asked to indicate their primary charging locations, with the option to select up to two answers. Charging at a wallbox at home was mentioned most often (32.7% of the answers), followed by a charging station owned by the employer (21.6%). A standard plug at home was reported as one of the most frequently used options by 18.4% of the responses while public normal and fast charging together were mentioned in 27.0% of the cases. This indicates that although 58% of the BEV drivers own a wallbox at home, it is not necessarily their primary charging location. Not all of them use this wallbox

[4] The base for these percentages is larger than 1,472 since people may drive both an ICE car and a BEV and are then counted twice.

as their primary charging solution and charging at the employer's or in public currently serve as solutions in many cases. Figure 4 shows the distribution of the most popular charging locations for different degrees of urbanization. In all areas, wallboxes at home are the most popular. However, the more urban an area is, other charging locations are used increasingly often. It is also apparent that most BEV drivers live in urban areas, and fewest live in rural areas.

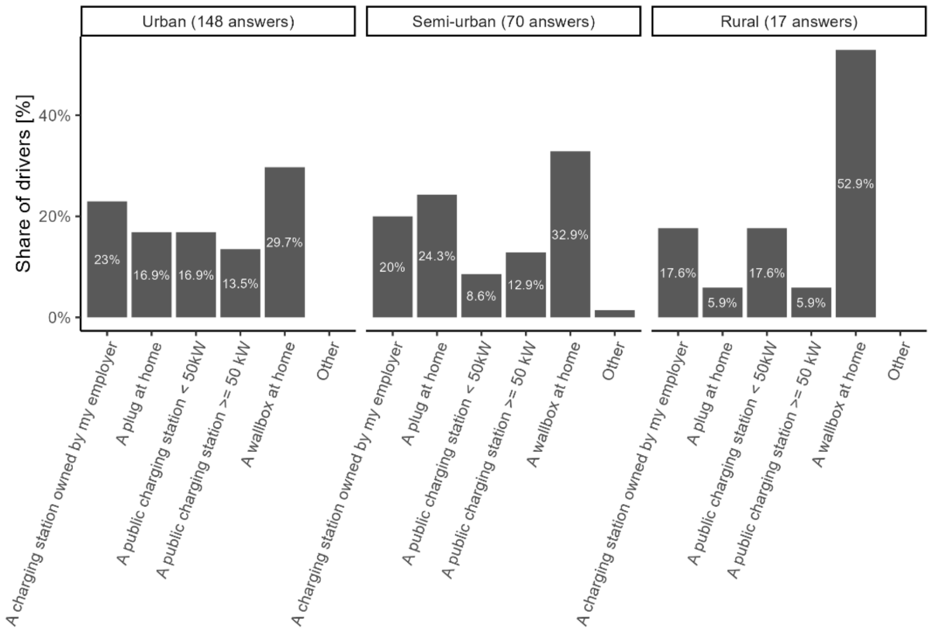

Figure 4. Most popular charging locations in different degrees of urbanization

Figure 5 shows that more than one-third of owner-occupiers prefer charging at their wallbox at home, while this is true for only a quarter of tenants. In contrast, public fast charging stations are more popular with tenants than with owner-occupiers.

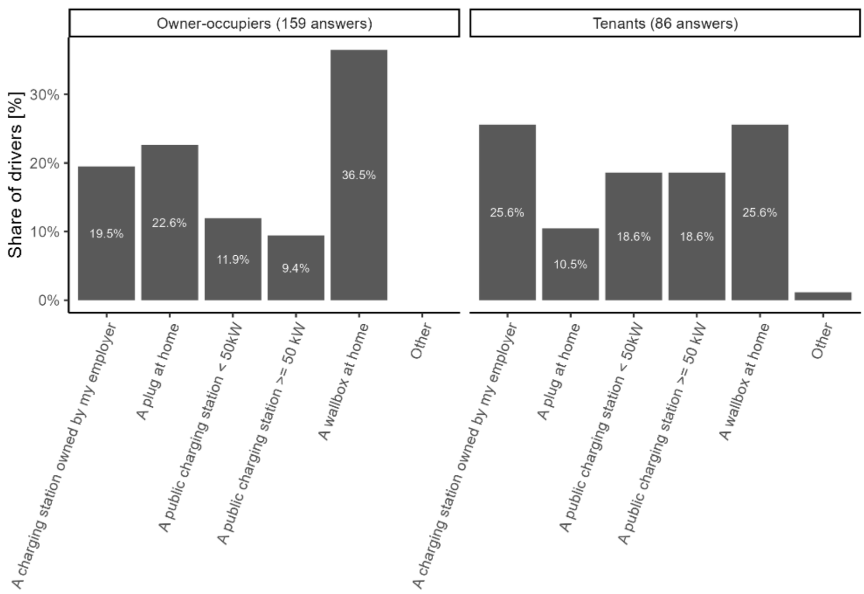

Figure 5. Most popular charging locations for owner-occupiers and tenants

3.2 Preferences for charging and charging infrastructure

Figure 6 shows that for more than 60% of the respondents, the availability of charging infrastructure within 250 meters is rather or very important when purchasing an electric vehicle. For around 17%, the availability of charging infrastructure within 250 meters would have no influence on their BEV purchase decision. Similarly, though to a slightly smaller extent, charging availability also plays a role when searching for an apartment: nearly 50% consider it important, while for approximately 25% it is not a relevant factor in this context.

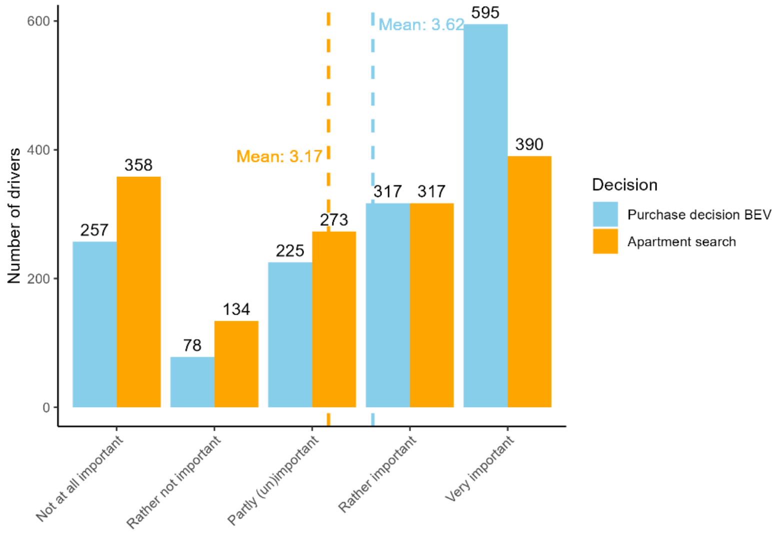

Figure 6. Importance of having a charging option close to home (up to 250 meters) when looking for an apartment when deciding whether to buy a BEV

Figure 7 shows the perceived attractiveness of different charging solutions for owner-occupiers and tenants. Owner-occupiers find most charging solutions significantly more appealing than tenants, except for charging at work and the solution that is shared with people of the same house at a lower price. Charging at one's own wallbox is the most appealing solution for both groups, followed by a shared solution with neighbours from the same house at a lower price and by charging at work. Shared charging solutions significantly increase their attractiveness when sharing goes along with lower charging prices. Interestingly, a shared solution in the residential area is less attractive than a public charging point.

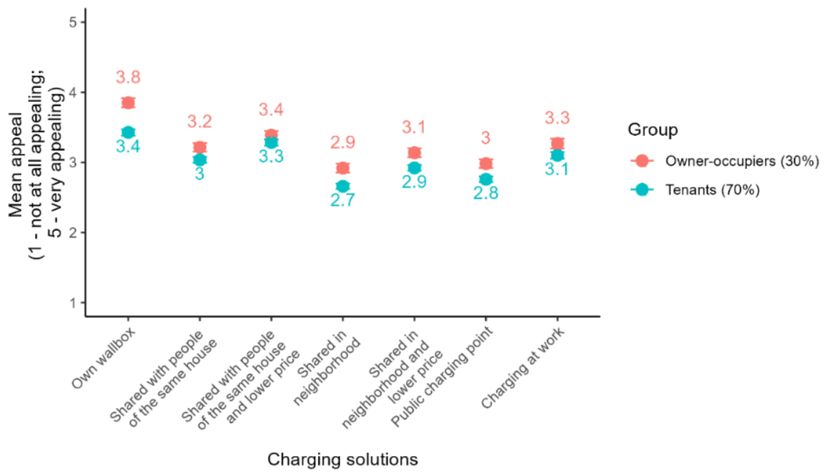

Figure 7. Appeal of different charging solutions. Error bars are standard errors.

Figure 8 shows the perceived attractiveness of the different charging solutions for three different income groups. People in the high-income group find all solutions the most attractive, always significantly more attractive than the low-income group, and sometimes significantly more attractive than the medium income group. In the low-income group, only the wallbox solution and the solution that is shared with people in the same house surpass the middle value of the scale and thus are on average appealing to the people in this group.

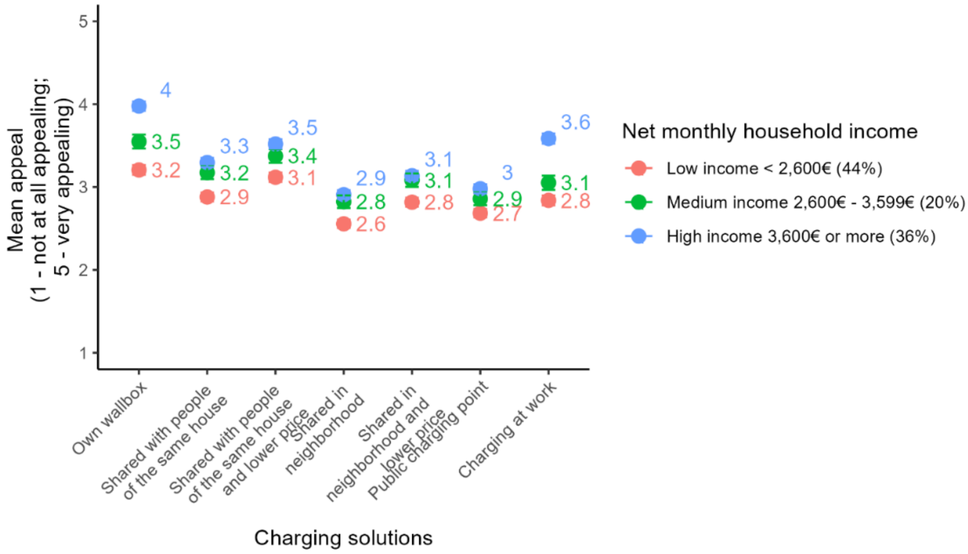

Figure 8. Appeal of different charging solutions for different income groups

Figure 9 shows the distribution of the maximum distance that the respondents would be willing to accept between their home and the next charging point for the different degrees of urbanization. People in urban areas would accept a mean distance of 250.0 meters (SD = 274.0, MD = 150), while people in rural areas would accept a significantly shorter mean distance of 212.9 meters (SD = 285.6, MD = 100). The distribution curves are shifted to the left (i.e., towards shorter distances) in more rural areas. Taking the whole sample, the residents of MURs would accept an average distance of 242.5 meters (SD = 282.5, MD = 101) for having a charging option available, even though most ICE car drivers (which represent a share of 86.6% on the entire sample) currently park at shorter distances (average distance of 91 meters, see above). Yet, 10% of the sample stated a distance of 0 meters, 25% would accept 40 meters or less and half of the sample would prefer a distance up to approximately 100 meters (median), while 7% would accept 1,000 meters.

Figure 10 shows the participants' willingness to pay for being able to drive 100 km with a (hypothetical) BEV, alongside their current expenditures for the same distance – either for fuel (ICE cars) or electricity (BEVs). On average, participants are willing to pay 6.84 EUR to recharge a BEV for 100 km of driving. This amount is lower than their current average cost of driving an ICE car (11.64 EUR/100 km) and also below the current BEV users' costs for charging their BEV (7.26 EUR/100 km). Interestingly, while the current electricity and fuel costs do not differ significantly between tenants and owner-occupiers, the willingness to pay does differ significantly between the two groups. While owner-occupiers would be willing to pay 7.42€ (SD = 4.83€, MD = 6.5€) on average, tenants –50% of which are part of the low-income group—are willing to pay 6.62€ (SD = 5.12€, MD = 5€).

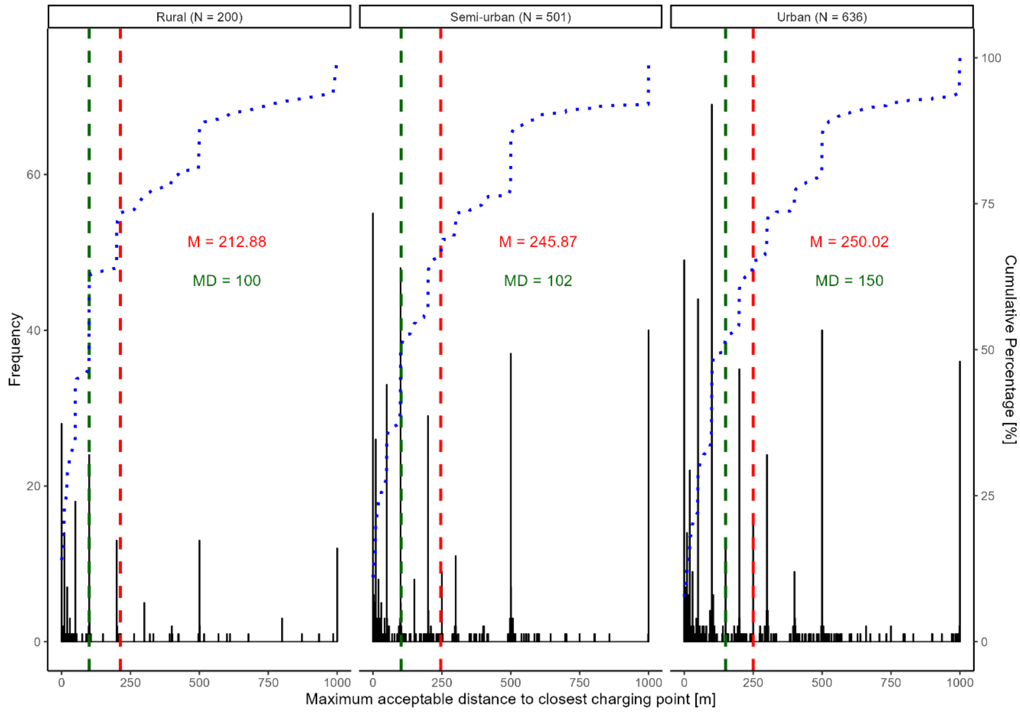

Figure 9. Maximum acceptable distance (in meters) from people's homes to the nearest charging point in rural, semi-urban and urban areas. Bars are frequencies, dotted line is cumulative percentage.

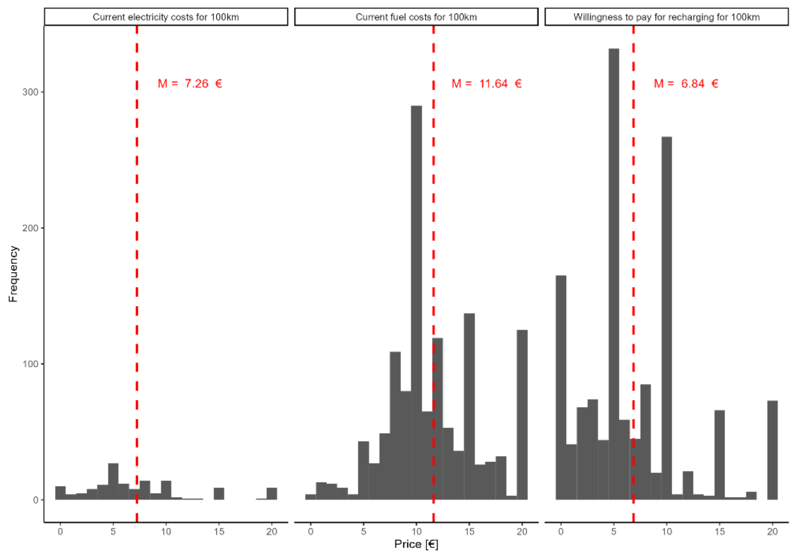

Figure 10. Current electricity and fuel costs as well as willingness to pay for recharging for 100 km.

4 Discussion and implications

Based on our results, we discuss four aspects yielding in implications for decision-makers in policy and industry: (1) the current state of BEV deployment, charging infrastructure, as well as charging and parking behaviour, (2) the attractiveness of different charging solutions and their distance, (3) the willingness to pay and (4) differences between user groups such as owner-occupiers and renters and different levels of income.

First, our results show that the current state of charging infrastructure deployment at MURs in Germany is low. Currently, only 16.6% of the permanent parking spaces in our sample are equipped with a wallbox and some more are equipped with ducting or cabling. Yet, two thirds of permanent parking spaces are not prepared for BEV charging at all. Less than 60% of the current BEV users have their own wallbox. Thus, having your own wallbox seems to be beneficial but not crucial for purchasing a BEV. The availability of charging infrastructure within 250 meters from home will also positively affect the decision to purchase a BEV. Moreover, people currently not only park at home, but also at various locations with varying distances to their homes. For example, especially in urban areas, more than a third of ICE cars are parked at the curbside. These findings imply that charging infrastructure can be shared and does not necessarily need to be installed at people's homes and can also be located elsewhere.

Second, our results indicate that a combination of different charging solutions at varying distances from people's homes appears to be effective. Combining private wallboxes, shared charging solutions within the same building and workplace charging appears to be a promising approach – especially if shared options are offered at a lower price. Charging solutions shared in the residential neighbourhood as well as public charging points are rather unattractive. Explanations might be the typically higher charging prices of these solutions, less control over the availability of the charging points and/or less trust between the actors involved. Regarding the distance between the home and the nearest charging point, our analysis shows that 25% of the sample would require a charging point located quite close to the home, while 50% are willing to accept distances of more than 100 meters—and more than 150 meters in urban areas. These findings indicate that parking areas with some walking distance might also be attractive for the deployment of charging infrastructure. Distances of 1,000 meters or more are only attractive for a small share (<10%) of the sample—and less so in rural than in urban areas. Note that most people would be willing to walk a longer distance to the nearest charging point than they currently walk to their parking or charging location. These findings suggest that a substantial share of residents of MURs might also accept solutions that go beyond the typical one-to-one setup located close to their home.

Third, our results show that the people's willingness to pay for BEV-charging is lower than what current BEV drivers pay for their charging electricity, and much lower than what people currently pay to fuel ICE cars. Assuming an average energy consumption of around 20 kWh per 100 km, the stated average willingness to pay of 6.84 EUR per 100 km corresponds to an electricity price of approximately 34,25 ct/kWh. This is close to the current average household electricity price in Germany (35.51 ct/kWh [23]) and below current electricity prices at public charging stations (AC or DC). This indicates that people expect charging solutions for MURs to offer electricity at household prices or lower.

Fourth, we identify differences between distinct groups such as owner-occupiers and tenants, as well as between individuals across different income levels. For example, owner-occupiers tend to be more u towards all presented charging solutions compared to tenants. A similar trend is observed when comparing the preferences of individuals in the high- and medium-income groups with those in the low-income group. For the people of the low-income group, only the wallbox solution and the solution that is shared with people in the same building are on average appealing—and charging at work might not work well. Moreover, owner-occupiers would also on average be willing to pay more than tenants for charging. In addition to possible correlations between these groups (i.e., 50% of the owner-occupiers belong to the high-income group and 50% of the tenants belong to the low-income group), further aspects such as regulatory and administrative barriers for installing a wallbox as a tenant might serve as explanations. Furthermore, there may be a tendency for people's willingness to pay for rented goods to be lower than for owned goods, unless the business model proves overall more attractive. However, understanding this aspect in the context of charging infrastructure remains subject to future research.

Therefore, policy and industry should consider the deployment of charging infrastructure also beyond individual wallboxes, particularly for residents of MURs. Alternative solutions can meet a considerable proportion of users' charging needs. More specifically, policymakers should consider the different charging solutions and their interplay in their roll-out plans focusing on future BEV adopters. Policymakers that seek to support the fast deployment and usage of charging infrastructure in MURs should focus on a combination of private wallboxes, charging points shared with people within one building, and workplace charging, while in parallel supporting the preparation of the industry and the future users for the deployment of the other charging solutions such as shared residential and public charging. Learning from best practices or examples seems to work in certain cases in particular for own wallboxes. For shared residential and public charging points barriers still need to be removed requiring policy support (e.g., by information campaigns, building trust among different actors sharing one charging point, reducing charging prices). Additional costs might be offset in the long term by their typically higher economic efficiency (e.g., due to higher utilization rates). Industry players should prepare accordingly and develop and test respective technologies including hard- and software. The willingness to pay household electricity prices or less for charging should be carefully considered by policymakers and industry players. For example, industry players could develop business models accordingly (e.g., including reduced charging prices for shared charging points). Furthermore, our results highlight that different solutions offer both advantages and disadvantages for the various groups considered, which policymakers should address—particularly when ensuring socially equitable access to charging infrastructure. This could include designing a fair pricing regime and supporting the deployment of more home-based charging infrastructure in selected areas.

A few limitations should be considered when interpreting our results. The results presented in this paper are based on survey data, which might be influenced by social desirability. Driving a BEV, let alone the availability of charging infrastructure, was a highly hypothetical scenario for most participants. As a result, answering the questions may have been challenging for some individuals, and responses might reflect overly idealistic scenarios, particularly regarding the willingness to pay. In addition, the fact that the share of BEV drivers in our sample was much higher than in the general population indicates that our participants might have been particularly interested in the topic, potentially leading to a slightly over-optimistic view. However, our sample was representative of the general population regarding other factors such as age, gender, income, and federal states. While the general findings may be transferrable to regions with similar cultural backgrounds, social structures, and transport decarbonization pathways, more specific conclusions regarding generalizability require a more detailed examination of the data. This further research could focus on interrelations between the variables, differences between user groups, as well as drivers and barriers that explain our findings. These factors may relate to individual-level aspects (e.g., psychological factors), regional (e.g., local availability of transport infrastructure), or national factors (e.g., regulation).

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